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Valuation of cycling facilities with and without controlling for casualty risk

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Abstract

Barrier effects can impact cyclists' travel time, level of comfort and risk of accidents. When eliciting the valuation of these elements, simultaneous estimation is called for, as the perceived level of comfort may depend on the accident risk. In this paper we present results of a choice experiment where cyclists traded off cycling time, separated tracks, intersections and, in one additional choice experiment, also casualty risk. We find that the utility of the two barrier-reducing attributes is almost halved when controlling for accident risk. We also translate the utility to a monetary scale, making the results applicable for cost-benefit analysis.

Keywords: accident, barrier, choice experiment, intersections, separated tracks, travel time

JEL: C35, C83, C93, D62, H41, H51, I18, R41, R42, R52

1. Introduction

For cycling there are barrier effects related to the infrastructure developed for motor vehicles (Stanley and Rattray 1978, Jacobsen *et al.* 2009), e.g., intersections with motorised traffic and the sharing of the road with motorised traffic. From the transport economics perspective these elements enter the generalised travel cost for cycling, and contribute to diselection of cycling as a mode (Elvik 2000). In addition to affecting cycling comfort/convenience and travel time, intersections and motorised traffic may also influence the risk of cycling, or cyclists' perceived worry/insecurity (Elvik 2000, Elvik *et al.* 2009, Jacobsen *et al.* 2009, Reynolds *et al.* 2009). Transport authorities can contribute to increasing bicycling as a transport mode by developing infrastructure, in quantity as well as in quality. The economic valuation of such publicly provided bicycling facility development can be assessed by choice experiments; whereby existing or potential bicyclists trade off, e.g. separated cycling tracks and grade separated crossings, against the time use, costs, or accident risk (Hopkinson and Wardman 1996, Wardman *et al.* 1997, Ortúzar *et al.* 2000, Abraham *et al.* 2002, Parkin *et al.* 2007, Tilahun *et al.* 2007, Wardman 2007, Börjesson and Eliasson 2012).

In this paper we present results of an internet-based stated-preference survey where cyclists faced choices between cycling route alternatives pivoted onto a recent cycle trip, involving separated tracks and grade separated crossings. In addition to these two barrier-reducing attributes, time use, and then also safety (fatalities/injuries on the section), was included in the choice sets. Due to the difficulty of establishing a credible payment vehicle for cycling facilities, the monetising of the relative values (part worths) was obtained from between-mode choices, where the alternative mode included a cost attribute (Wardman *et al.* 1997, Wardman 2007, Börjesson and Eliasson 2012). Our study was generalised to fit any reference cycling trip for transport reported, excluding trips under 10 minutes and access trips to public transport (also omitting recreational and exercise cycling). This generalised approach was adapted to an internet-based survey for a sample of the Norwegian cycling population. A novel contribution from this study is the simultaneous choice-based valuation of barrier-reducing facilities and accident risk, as well as the comparison against choices not including the accident risk attribute.

The remainder of the paper is arranged as follows: The next section provides theoretical foundations for the economics of cycling for transportation and the valuation of cycling facilities. In the third section the methodology for choice experiments is described, while the internet-based survey material is described in the fourth section. The fifth section provides the resulting estimates of the part-worths of cycling facilities, casualty risk, and time savings, as well as the formal test results. The findings are discussed and concluded in the last section.

2. Theoretical and methodological approaches

2.1. Barrier effects, bicycle compatibility, and bicycling demand effects from facility levels

Roads and motor vehicle traffic create barriers to cyclist and pedestrian and travel (Stanley and Rattray 1978, Hine and Russel 1993), both in terms of impeding access and causing delay and discomfort.[1] From the transport planning and engineering approaches, several instruments for measuring "level of service" (LOS) or "compatibility" for cycling have been developed since the ninetees (Dixon 1996, Landis 1996, Harkey *et al.* 1998, Pikora *et al.* 2002, 2003). Rietveld and Daniel (2004) assessed the effect of policy-related variables controlling for geographical aspects and population characteristics, using travel survey data aggregated at the city level in the Netherlands. They found a clear negative effect on the propensy to cycle from the number of stops (or turns off) per unit distance. Furthermore, relative speed of cycling compared to car speed contributed positively to the cycling demand. They also found a significant negative effect from injury risk. Parkin *et al.* (2008) also

[1] The barrier effect may be regarded a type of congestion cost (Litman and Doherty 2009), a negative external effect from motorised transport on cycling. The choice of transport mode yields several types of negative external effects (Hanley *et al.* 1997). E.g., driving a car yields emissions, accident risks, and congestion that are not fully internalised by the driver; some of the costs are borne by others, by the society. Cycling produces relatively minor negative external effects compared to motorised transport, and a change from car driving to cycling/walking would thus reduce external costs from transport. Increased cycling/walking may also yield additional positive external effects, for society, related to land use, the urban environment (liveability), and the public health (Elvik 2000, Litman 2003, Pucher and Dijkstra 2000, 2003, Rietveld and Daniel 2004).

controlled for geographical aspects and population characteristics in their analysis of the propensity to cycle to work in England and Wales, applying UK 2001 census data. They estimated a positive effect (although relatively weak) on cycling to work from the quantity of off-road cycle routes; the positive effect was more strongly related to the pavement quality on these cycle routes.

2.2. Valuation of bicycle facilities based on choice experiments

Choice experiments enable hypothetical valuation of changes in the attributes of goods or services, such as bicycling trips' time use, facility/pleasance, uninterruption, injury/fatality risk, etc (Bovy and Bradley 1985, Wardman *et al.* 1997, Rizzi and Ortúzar 2003). The respondents carry out a series of choices (trade offs) between two or more alternatives (options) described by the attributes (or attribute levels), and do not need to state values directly for each attribute; instead the attribute values ("part-worths") are estimated indirectly from the respondents' choices. If the hypothetical choices are related to (pivoted on to) some actual behaviour ("a recent bicycle trip"), this is expected to create realism as well as mimicking how choices are carried out in real life (Ben-Akiva and Lerman 1985, Louviere *et al.* 2000, Hensher and Greene 2003).

Wardman *et al.* (1997) conducted choice experiments to value several cycle facilities. They included travel time and cost of the alternative mode (either car or bus), travel time for cycling, three different levels of on-road facilities for cycling and destination facilities, as well as weather. The valuation of the bicycling facilities and the bicycling time was thus achieved by dividing their coefficients by the cost coefficient for the alternative mode. The monetised value of a cycling facility is calculated as the ratio of the marginal utility of the bicycling facility over the marginal utility of bicycling time times the ratio of the marginal utility of bicycling time over the marginal (dis)utility of the cost of the alternative mode. In the case of Abraham *et al.* (2002), conducting a route choice experiment for cyclists (in Calgary, Alberta), the payment mode was somewhat related to bicycling. They used charges for a change room with lockers to arrive at estimates of value of bicycling time. However, this payment vehicle is not a direct cost of cycling (similar to fuel costs or tickets, for car driving and public transport). In their choice experiment they entangled stops at crossings with the time attribute, treating them as a joint variable. If there are differences in comfort/enjoyability of the time spent, that is, differences in the direct utility of travel time, this utility difference should appear in the value of time estimate from time spent in free flow versus waiting at a crossing (DeSerpa 1971).[2] Parkin *et al.* (2007) specified a logit model for the probability that cycling is

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[2] Tilahun *et al.* (2007) describe a choice experiment where respondents faced pair-wise choices between bicycle routes with different facilities, but where each facility was compared with all other facilities. "For example, an offroad facility (A) is compared with a bike-lane no on-street parking facility (B), a bike-lane with parking facility (C), a no bike-lane no parking facility (D) and a no bike-lane with parking facility (E)" (p. 290). They applied an adaptive choice design, such that the travel time for the route alternatives with better facilities was changed according to previous choices, with initial time of 40 min for the best facility route and 20 min for the worst facility route. The route alternatives were described by video clips, plus an indication of travel time. They estimated a bike lane facility valuing 16.41 min, a no in-street parking valuing 9.27 min, and an off-road facility

acceptable.[3] From a test of the model, based on a small sample of 144 commuters in Bolton, MA, they found significantly positive effect from the proportion of off-road cycle routes as well as cycle lanes adjacent to the road. They found negative effects on route acceptability from signal-controlled junctions, as well as from turns crossing the direction of oncoming traffic. The latter feature involves a considerable accident risk for bicyclists (Stone and Broughton 2003, Elvik *et al.* 2009).

Regarding the elements of safety and insecurity (worry/discomfort) in bicycling choice, Hopkinson and Wardman (1996) represent an early contribution. They conducted a route choice experiment for cyclists, where particular cycling facilities would bring about safety improvements. The facility development involved a "high quality, totally segregated cycle path along the railway line which would be tarmaced and under continual camera surveillance", remarking that "given that the value of cycling facilities, for example in terms of risk reduction, can be expected to depend on the time spent using the facility, cycling facility and time are treated as a joint

valuing 5.13 min, in terms of being willing to add this travel time relative to a 20 min trip lacking these facilities.

[3] The logit model had the following form: Pr(A) = $1 \big/ 1 + e^{Z_{ij}^U - Z_{ij}^A}$, where *i* refers to routes and *j* to junctions, Z_{ij} represents the overall risk of a journey; and the "utility of cycling being unacceptable (*U*), Z_{ij}^U , is arbitrarily set to zero and the utility of cycling being acceptable (*A*), Z_{ij}^A, is a linear function of the variables" (Parkin *et al.* 2007, p. 370). The specification of Z_{ij}, with types of routes and junctions represented by dichotomous (presence of particular condition) or continuous variables (intensity of particular condition), would involve contributory effects to cycling demand (or acceptability). In addition to journey attributes, the function can also include individual characteristics, e.g., age and gender.

variable" (p. 243). They also introduced a payment vehicle, a charge to use the segregated cycle path, making it a kind of toll road for bikes. Ortúzar *et al.* (2000) analysed mode choice in relation to a proposed segregated network of cycle ways in Santiago de Chile. The mode alternatives were bicycle, or bicycle combined with metro (access trip by bike to station), against the current mode (car or public transport). Both bicycle and other transport mode alternatives were described by travel time and cost. For the hypothetical new cycle network the payment vehicle was a bicycle shelter charge. They used the choice experiment for cycle demand estimation, given the construction of segregated cycle ways, finding that it could increase the bicycle share from approximaetely 1.5% to nearly 6%, while stressing the importance of trip length (in time) as a limiting factor.

Wardman *et al.* (2007) combined revealed preference and choice experiment data to elicit valuations and predict demand effect of measures encouraging cycling. Somewhat similar to Hopkinson and Wardman (1997) and Abraham *et al.* (2002), Wardman *et al.* (2007) treated cycling facility and time as an interaction variable. A main purpose of the choice experiment was to assess the effect on the time value for cycling with different cycling facilities and to estimate bicycling demand. One sub-sample valued time on three of the following cycling road facility specification: major roads with no cycling facilities, minor roads with no cycling facilities, non-segregated on-road cycle lanes, segregated on-road cycle lanes, and completely segregated cycle lanes; while the other sub-sample valued time with the following destination facilities: parking facilities at destination (outdoors and indoors), and shower/changing facilities at destination. The estimated value of cycling time was the same for major and minor roads with no cycling facilities, while it was reduced to approximately a third in the case of non-segregated cycle lanes; close to the time value for motorised commuting transport, estimated at 6.5 pence per min, or GBP 3.90 per hour, in 1999 values.[4] The difference of approximately 12 pence per min, more than 7 GBP/h, yields the estimated value of non-segregated on-road cycle lanes. The value of time was further halved, approximately, for segregated cycle lanes; and relative to no cycling facilities the estimated implicit value is approximately 9.50 GBP/h for segregated cycle lanes. Regarding destination facilities, outdoor parking was found equal to 2.5 min travel time saving (ca 48 pence per min), indoor parking 4.3 min, and shower/changing facilities (in addition to indoor parking) 6 min (ca 115 pence per min).

In a recent paper, Börjesson and Eliasson (2012) present a two-step choice experiment for bicyclists in Stockholm. In the first step the cyclists chose between cycling and an alternative (second-best) transport mode, involving travel time, travel cost for the alternative mode, and the share of the bicycle time on a separated path. In the second step, the cyclists faced a pairwise choice between bicycle routes, "differing in terms of travel times, number of signalised intersections, total waiting time at those intersections and whether there was a bicycle parking facility at the

[4] The ratio of the cycling travel time coefficient with no facilities (Time-Y) and the motorised commuting travel time coefficient (Time) is 2.97, from the MNL in Table 1, in Wardman *et al.* (2007), thus implying a cycling travel time value of slightly more than 19 pence.

destination" (p. 677). Similar to Wardman *et al.* (2007), Börjesson and Eliasson (2012) found considerably higher value of cycling time, in mixed street traffic, than value of time on the alternative motorised mode (mostly public transport); that is, 15.9 EUR/h compared to 8.7 EUR/h (or 17.6 EUR/h compared to 9.3 EUR/h evaluated at average sample income and baseline travel time below 40 min). The value of cycling time is reduced to 10.5 EUR/h (or 12.2 EUR/h) for cycling on separate cycling path, implying a value of cycling on a separate path, relative to cycling in mixed traffic, equal to EUR 5.4 per hour. They find a value of one signalised intersection equal to 1.02 bicycling minute (or 1.1 bicycling minutes for one signalised intersection in addition to the delay). Using the bicycling value of time in mixed traffic, 15.9 EUR/h, the monetised value is estimated at 0.27 EUR (0.29 EUR).

2.3. Modelling choice experiments involving policy-related attributes of bicycling compatibility – separate paths, elimination of crossings, and reduced accident risk

Transport authorities can respond to bicycling facility demand by developing infrastructure, in quantity as well as in quality. The policy measure related to stops/crossings involves the construction of grade-separated crossings that will eliminate the need to stop (Elvik 2000, Elvik *et al.* 2009). Building on the referred choice experiments of bicycling for transport, a two-step modelling of the valuation of policy-related attributes for bicycling is proposed. Practically, this is due to the challenge of finding an appropriate payment vehicle for cycling; there is no direct “out-of-pocket” cost of cycling in Norway, and hypothetical payment vehicles could bring along a credibility problem for the choice scenario.[5] Thus, a first step comprises choices between cycling and an alternative mode involving out-of pocket costs, similar to the approaches by Wardman *et al.* (1997), Ortúzar *et al.* (2000), and Börjesson and Eliasson (2012); which will yield an implicit valuation of time in cycling. In the second step the time valuation is applied for valuation of other bicycling attributes. The following random utility functions apply to the first step choices between cycling and an alternative paid transport mode (suppressing notation for individuals):

$$\begin{aligned} U_B &= \mathrm{ASC}_B + \beta_{t,B,SEG} \cdot t_{B,SEG} + \beta_{t,B,NO} \cdot t_{B,NO} + \varepsilon_B \\ U_A &= \beta_{t,A} \cdot t_A + \beta_{c,A} \cdot c_A + \varepsilon_A \end{aligned} \tag{1}$$

where U_B and U_A refer to, respectively, bicycling utility and alternative mode utility; $t_{B,SEG}$ and $t_{B,NO}$ refer to, respectively, bicycle travel time on segregated cycle path and bicycle travel time in mixed street traffic; t_A is the travel time on the alternative motorised mode; c_A is the cost of the alternative mode; and $\beta_{t,B,SEG}$, $\beta_{t,B,NO}$, $\beta_{t,A}$ and $\beta_{c,A}$ are the corresponding coefficients; ASC_B refers to an alternative-specific constant; and ε_B and ε_A refer to error terms assumed to be iid extreme value (Gumbel) distributed, yielding a logit structure of the choice model (McFadden 1974).

The following random utility functions apply to the second step choices between different bicycling trips:

[5] We did develop a prototype scenario involving a bicycling toll road, but it was not implemented.

$$U_j = \beta_{t,j} \cdot t_j + \beta_{\mathrm{SEP},j} \cdot \mathrm{SEP}_j + \beta_{\mathrm{CRO},j} \cdot \mathrm{CRO}_j + \beta_{\mathrm{CAS},j} \cdot \mathrm{CAS}_j + \varepsilon_j \tag{2}$$

where U_j ($j \in C$, the choice set) refer to bicycling trip alternatives; t_j is the travel times; SEP_j is the share of separated cycle path (off-road cycle/walking path or on-road cycle lane); CRO_j is the number of crossings with motorised transport (per trip length); CAS refers to the number of fatalities and serious injuries per trip length; and $\beta_{t,j}$, $\beta_{\mathrm{SEP},j}$, $\beta_{\mathrm{CRO},j}$ and $\beta_{\mathrm{CAS},A}$ are the corresponding coefficients; and ε_j refers to the error term assumed to be iid extreme value distributed. The value of bicycle travel time in mixed street traffic, from the between-mode choice experiment, can be applied for monetised valuation of separated cycle path, crossings, and casualties in the within-mode choice experiments.

Consistent with the fundamental axiom of consumer theory, a choice of alternative j implies that $U_j > U_k$, or $\Pi_j = \Pi\{U_j > U_k\}$, for all $k \neq j$ (Beggs *et al.* 1981). The implicit valuation of the attributes in the alternatives can be estimated by logit modelling. Heterogeneous preferences for these attributes can be handled by randomised parameters, such that these follow a distribution in the population. This yields a mixed logit model specification, where choice probabilities have to be simulated:

$$E(\Pi_j) = \int_{\boldsymbol{\beta}} \frac{\exp(V_j)}{\sum_{k \in C} \exp(V_k)} f(\boldsymbol{\beta}) d\boldsymbol{\beta} \tag{3}$$

where V_j refers to the index (deterministic) portion of the random utility function; $\boldsymbol{\beta}$ is the parameter vector, and $f(\cdot)$ represents a density function, the mixing distribution of the parameters. The mixed logit model also allows correlation among choices made by an individual. Not allowing random parameters would reduce (3) to a MNL (Train 2009).

We will assume that all random parameters follow a normal distribution. Fixing the denominator (the cost parameter in the first step between-mode choice and the time parameter in the second step choice between generic bicycling alternatives), the additive utility function implies that parameters can be interpreted as marginal valuations; and the value ratios will follow the same distribution as the numerator (Ruud 1996, Revelt and Train 2000).

2.4. Choice experiment design

De Jong *et al.* (2007) describe attribute design for pair-wise choices; a near-orthogonal design avoiding choices with dominant alternatives. It applies to hypotehetical choices pivoted on reported trip characteristics, yielding reference (base) levels for the attributes. In each choice pair one of the alternatives includes the base level for the attributes of the choice alternatives. For all attributes, there are two levels with a higher value than the base value and two levels with a lower value than the base value. Regarding travel time it refers to door-to-door journey time, while travel cost is the total cost for the one-way journey. As the respondent may not been able to calculate the exact cost of the journey, the researcher could adjust respondents' stated cost, based on reported trip distance, fuel type and perceived fuel efficiency. Regarding other attributes than time and cost, these can also be built around reported levels of a reference trip, or estimated with respect to, e.g., base distance (travel time) level.

3. The survey design

3.1. An overview of the bicycling attributes and choice experiment

The following choice experiments will be applied for valuing bicycling time savings, as well as bicycling facilities, related to barrier and insecurity effects, testing for the effect when also including a specific accident risk attribute:

1. Mode choice experiment between cycle and car or public transport, involving the attributes total cycle time (t_B), total in-vehicle time (t_A), total cost of the trip with car or public transport (c_A), and binary attribute variable segregated cycle path (SEG)
2. Within-mode choice experiment involving the attributes total cycle time (t), share of separate cycle path (SEP), and number of stops/crossings (CRO)
3. Within-mode choice experiment involving the attributes total cycle time (t), share of separate cycle path (SEP), number of stops/crossings (CRO), and number of casualties (CAS)

There are eight pair-wise choices per respondent in the between-mode choice experiment, and there are six pair-wise choices per respondent in the within-mode choice experiments.

3.2. Design for the between-mode choice experiment

The first choice experiment involving bicycling is a between-mode choice experiment, an alternative-specific choice between bicycling (*B*) and a second-best alternative paid transport mode (*A*), either car or public transport, against the reported cycle trip. This purpose of this experiment is to establish a value of travel time for bicycling, which will then be used for implicit valuation of other bicycling attributes in within-mode cycling choices omitting a payment vehicle.

Figure 1 about here

In the between-mode choice experiment the "base time" was not based on the reference bicycle trip time, but was randomly assigned to respondents (either: 15, 21, 26, 32, 38, 43, 52, 58, 61, or 68 min). The respondent is asked to choose an alternative mode (car or public transport) to replace the bicycle trip (Figure 1). The "base time" of the alternative mode (car or public transport) is 0.4 times the "base time" of bicycling, while the "base cost" of the alternative mode, in NOK, is 1.4 times the "base time" of bicycling, below 30 min; 0.6 times the "base time" of bicycling, between 30 and 60 min; and 0.35 times the "base time" of bicycling, above 60 min. There where three levels of each of these attributes; ±30% for "base time" below 30 min and ±25% for "base time" of 30 min or less; and ±30% relative to “base cost”. The choice experiment will be a randomised factorial design, with no blocks of choices with reducdant pairs of alternatives, following de Jong *et al.* (2007).

3.3. Design for the within-mode choice experiments

3.3.1. Time, share of separate cycling paths, and number of crossings

The following table displays the bicycling travel time attribute base levels and variation with respect to the base level, for application in the second step within-mode choice experiment (Table 1).

Table 1 about here

For the share of separate cycling path it was deemed necessary to simplify the attribute structure, including a disconnection from stated reference levels (Table 2).

The design of attribute levels for number of stops (due to crossings) followed more closely the reported levels of the respondents' reference trip; although this implied a problem for the variation over attribute levels when the reported base was 0 or 1. When the base number of stops is zero, "level –1" and "level –2" also has to be zero; and similarly when the base number of stops is 1, the relative change has to be –1 in both "level –1" and "level –2" (Table 3).

Table 3 about here

In a first within-mode choice experiment, the respondent is asked to choose between bicycling trips involving the attributes total cycle time (*t*), share of separate cycle path (SEP), and number of crossings (CRO); altogether six pairwise choices (Figure 2).

Figure 2 about here

3.3.2. Including a safety attribute – the number of casualties estimated for the reference trip

A pertinent issue for our research was the extent to which barrier/insecurity elements could be valued in choice experiments, conditioning versus not conditioning on a particular accident risk attribute. The within-mode choice experiment without an accident risk attribute (Figure 2) could be tested against a choice experiment including an accident risk attribute. A way of presenting accident risk in choice experiments is to present numbers of casualities in cycling accidents on the reference route section of the cyclist (Rizzi and Ortúzar 2003). However, differently from travel time, separated cycle sections, and grade separated crossings, the number of casualties, or casualty risk, is not a type of information that the cyclist can be expected to report. In a generalised choice experiment for different reference trips, the casualty risk (the annual casualty number) can be estimated from the other trip information. More precisely, our approach attaches an annual expected number of fatalities and serious injuries on a cycle road of a certain length with a certain motor vehicle density (annual average daily traffic, AADT) at shared facilities and/or intersections. Initial AADT levels were assigned to each respondent based on the urbanisation level at the respondents' place of residence, simplifying to three levels only: 12,000 for city, 6,000 for other densely populated area, and 2,000 for rural area (Elvik 2008). The initial AADT level could be adjusted one level upwards or downwards by the respondents' own assessment of traffic density.

Reported trip time is applied for calculating trip length, assuming some average bicycling speed, 12 km/h. The conversion from reference trip time (midpoints) to trip length means that in 15 min a trip by cycle will cover 3 kilometres [(15/60) · 12], and so on (Elvik 2008). Table 4 shows the procedure of estimating base levels of casualties (serious injuries and fatalities) on cycle road sections of different length and with different AADT levels at shared facilities and/or intersections.

Table 4 about here

The basis for the calculations shown in Table 4 was the actual casualty numbers in Norway from 1998 to 2005, but adjusted for underreporting; that is, the number of serious injuries was multiplied by 1/0.7 (Elvik and Borger Mysen 1999). Further adjustment upwards was considered necessary for the shortest trips to ensure large enough integer values to allow variation up and down from the base level (Elvik 2008). Furthermore, it is known that bicycle injuries are incompletely reported in official Norwegian accident statistics, although less incomplete for serious injuries than for slight injuries (Veisten *et al.* 2007).

Regarding the casualty attribute range and levels, it followed the design for pair-wise choices from de Jong *et al.* (2007), similarly to the time attribute, with two lower levels than the base and two higher levels than the base. The two levels with higher values (worse levels) were set to, respectively 15% and 30% above the base level (rounded to integer), while the two lower levels (better levels) were set to, respectively 15% and 30% below the base levels in Table 1. The exception is for base levels below four casualties, where the increases were set to 1 and 2, and reductions set to -1 and -2, from the base levels (as the low base level would not yield differentiation applying 15% and 30% changes). As for the first within-mode choice experiment, also the second, including the specific accident attribute, were presented over six pairwise choices (Figure 3).[6]

Figure 3 about here

[6] The wave 2 choice experiment included also an opt-out ("do not know") option; and while this might be included in the analysis (Veisten *et al.* 2012), it will be omitted in this study, primarily for the purpose of comparing the wave 1 choice experiment (omitting the safety attribute) with the wave 2 choice experiment (including the safety attribute).

3.4. Survey development

In our project we followed the same respondents in two waves of surveying. In the first wave they described a recent cycling trip which yielded reference values for the choice experiments; they also entered the between-mode choice experiment and the first between-mode choice experiment. In the second wave the accident attribute was introduced, with reference level defined from the time use on the reference trip reported in the first wave.

The development of the survey was initiated in 2008; at the end of April 2008 draft scenarios of road safety measures and examples of risk change descriptions, related to the second wave of the bicycling survey, were presented in a focus group of eight participants. Although the participants indicated understanding of probability communication devices, like grids with black squares representing fatalities (Alberini and Chiabai, 2007), we opted for the approach by Rizzi and Ortúzar (2003), presenting and altering fatality/injury numbers instead of fatality/injury risk figures. In May 2009 a small pretest of the first wave of the bicycling survey, including the registration of the bicycling reference trip, the between-mode and the first within-mode choice experiments, was carried out among colleagues. Although no specific pilot testing was carried out among bicyclists, similar survey and choice experiment structures were tested for other transport modes, in two waves, during the first part of 2009 (Ramjerdi *et al.* 2010, Veisten *et al.* 2012). For the second wave, the pilot testing of the accident attribute among car drivers resulted in a reduction from 25 and 50% up and down from the base level of casualties, to 15 and 30% up and down from the base level; due to the indicated strong preference for the alternatives with lowest number of casualties.

Our main two-wave survey was applied to a fairly large sample of the Norwegian population, and carried out, first in June and July 2009. Due to mismatch of the routing of the respondents from wave 1 to wave 2 (Samstad *et al.* 2010), a new two-wave survey was carried out in April and May, 2010. Only the results of the latter 2010 data, where respondents were correctly routed between wave 1 and wave 2, are reported here. The two-wave internet-based survey was carried out via e-mail recruiting from the national internet panel of *Synovate Norway*. There were 2408 bicycling respondents in wave 1, and 1573 (65.32%) of them also participated in wave 2. In the analysis we will only consider those respondents responding to both wave 1 and wave 2 (*n*=1573). Figure 4 illustrates the sampling procedure of the study.[7]

Figure 4 about here

In addition to questions about the reference bicycle trip and choice experiments, the surveys also included other elements. The questionnaire structures were the following, respectively for wave 1 and wave 2:

[7] According to Synovate Norway, our response rates were common for their internet panel, and they applied techniques to adjust the sample to population figures, i.e., distributions of gender, age, and regional appurtenance. Synovate Norway, formerly *MMI (Markeds- og Mediainstituttet) AS*, was part of the international opinion research company Synovate when carrying out our survey. Synovate Norway joined the Ipsos Group on 1 January 2012 and is now called *Ipsos MMI* (http://ipsos-mmi.no).

Wave 1:

- Introductory questions about individual characteristics
- The reference bicycle trip
- Between-sample choice experiment
- Within-sample choice experiment (omitting accident risk attribute)
- Questions about bicycling for transport
- Debriefing questions and more questions about individual characteristics

Wave 2:

- Introduction to the issue of fatality/injury risk and casualty numbers
- Scenario for change in casualty numbers
- Within-sample choice experiment including accident risk attribute
- Respondents' income / ability-to-pay
- Debriefing questions (fatality/injury risk beliefs, accident experience)

4. Results

4.1. Descriptive analysis

Table 5 lists the means and ranges of individual characteristics.

Table 4 about here

Before the statistical analysis of the choice experiments some respondents where excluded if not meeting certain requirements related to their reference trip. Respondents were excluded from wave 1if they reported a references trip of over 100 minutes, or over 50 km. Respondents that reported what was considered an unrealistically high number of intersections, i.e., more than 10 per km, were also excluded. Finally, respondents for whom an average speed of over 30 km/h was calculated were also excluded, based on the assumption that their reported trip was recreational (for the purpose of exercising) rather than cycling for transport (Ramjerdi *et al.* 2010).

4.2.Statistical analysis

Table 6 shows the results of the logit modelling of the between-mode choice. Two different models were estimated, where the righthmost model represents equation (1), including two bicycle time parameters, one for no segregation and one for segregation (indirect valuation of segregated cycle path, via time valuation). The leftmost model includes a single bicycle time parameter and a specific segregation variable (direct valuation of segregated cycle path). The mixed logit version includes a normally distributed error component in the utility function of bicycle, with standard deviation (SIGMA_bic) estimated from the data. This specification is chosen in order to control for differences in the preference for cycling as such, then presumably measuring the marginal utility of the attributes more precisely.

Table 6 about here

The leftmost models fit the data slightly better, and might also be considered more in line with the choice experiment presentation. The bicycling value of time estimates from the mixed logit models are higher than those from the MNL, but the differences are not statistically significant. The goodness-of-fit measures of the mixed logit models are substantially better than those of the MNL versions. The value of SIGMA_bic is relative high compared to the ASC_bic indicating that there is a relatively high (unobserved) heterogeneity in preferences for bicycling compared to the alternative mode. The value of time in the alternative mode, based on mixed logit modelling, is (NOK 87 per hour in the leftmost model and) NOK 86, in the rightmost model, with 95% CI of (64,109). The bicycling value of time estimates from the mixed logit models are higher than those from the MNL, but the differences are not statistically significant. The "average" value of bicycle time, from the leftmost model, is 164 (140,188). The value of bicycle time in mixed traffic is NOK 190 (162,218) per hour, while it drops to NOK 141 (120,170) on segregated paths.[8] The indirect value of a segregated path, per trip, is then NOK 49 per hour travelled; while the direct valuation, from the leftmost model, yields NOK 87.3 hour travelled.[9]

Table 7 displays results of the second-step within-mode experiments, representing equation (2), respectively without (wave 1) and with (wave 2) the accident risk

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[8] These value estimates are approximately 20-30% higher than similar estimates based on the 2009 data (Ramjerdi *et al.* 2010).

[9] The calculation is based on average reported bicycle time of 27.8 minutes. The value of 35.6 NOK is multiplied by 60/27.8 to obtain the value of 87.3 NOK. Note that the average travel distance value is rather high as only trips over 10 minutes are included in the study.

attribute. We present pooled models including the choices in both waves. We differentiate between generic modelling, with common parameters in both waves for time use, crossings and separated paths/lanes, and wave-specific modelling for all parameters except the bicycling time parameter. We include a scale parameter for data of wave 2 in order to measure the relative differences in error variance.[10] Note that the scale parameter does not affect the WTP values as the scale simply cancels out when calculating parameter ratios. The specification of the mixed logit model is somewhat different from the approach in the between-mode modelling. Here we assume random coefficients that are normally distributed. We allow thereby for unobserved taste variation with respect to separate paths, crossings and casualty risk. The time attribute is assumed to be fixed in order to make the calculation of the WTP values easier.[11] The constant term (ASC) is now related to the left-hand-side alternative and it is expected to be statistically insignificantly different from zero.

Table 7 about here

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[10] It is likely that the error variance in the within-mode experiments differs between wave 1 and wave 2. The hypothesis is that the error variance is higher in wave 2 because the inclusion of the casualty attribute adds complexity to the choice decision. The relative impact of unobservable factors is therefore likely to be more prominent in wave 2. The scale parameter for wave 1 is normalized to one while the scale parameter for wave 2 is estimated from the data. A lower scale parameter will indicate higher error variance (Train 2009).

[11] For estimation of WTP based on choice experiments where all parameters are random, see e.g. Hensher and Greene (2003) and Daly *et al.* (2012).

The scale parameter for wave 2 is lower than one, as expected, implying higher error variance in wave 2 choices than in wave 1 choices. The mixed logit specification is preferable, compared to MNL, in light of the substantial improvement in goodness-of-fit and the fact that most standard deviations of the random parameters are relatively high, except for the one related to crossings in wave 2 (SIG_CRO_w2). The calculation of parameter ratios is therefore based on the mixed logit results, whereby all numbers are average values of the estimated distribution.

First, we test if the inclusion of the casualty attribute would have a significant impact on the marginal utility of barrier effects, that is (lack of) separated paths/lanes and crossings. Applying a likelihood ratio test, we tested the null hypothesis of equal parameters for the bicycle barrier parameters. The underlying null hypothesis in the (restricted) generic model is:

$$H_0\text{: B\_CRO\_w1=B\_CRO\_w2 and B\_SEP\_w1=B\_SEP\_w2}$$

For the mixed logit model versions (where the null-hypothesis also comprise equal standard deviations of the random parameters), the likelihood ratio test statistic is:

$$-2(-8242.755+8201.474) = 82.562 > 9.49$$

where 9.49 is the critical value for p=0.05 with four degrees of freedom.[12] Thus, we can reject the null hypothesis and conclude that the marginal utility of barrier effects is not independent of the inclusion of the casualty attribute. As, in Table 7, the valuation of barrier effects is higher in wave 1 than in wave 2.

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[12] The likelihood ratio test statistic for the MNL versions is: $-2(-9304.911+9280.718) = 48.39 > 5.99$, where 5.99 is the critical value for p=0.05 with two degrees of freedom.

One stop (elimination of one stop/crossing) obtains a value of 1.20 cycling minutes in the joint model, but the wave 1 estimate is 1.41 min compared to 0.78 min in wave 2. Applying the average value of bicycling time of 164 NOK/h (2.73 NOK/min), yields 3.27 NOK per elimination of stop per cycling trip, in the joint model; 3.85 NOK in wave 1 vs. 2.14 NOK in wave 2.[13] A marginal increase of the share of separate cycling paths, either a 1% increase of on-road cycle lanes or off-road cycle paths, obtains a value of 0.50 cycling minutes in the joint model, or 1.24 NOK; 0.49 min and 1.34 NOK in wave 1 vs. 0.29 min and 0.78 NOK in wave 2. For an average trip length of 6.4 km (Table 5), the implicit value (for the joint model) of a km separate cycling facility is then 1.24·(100/6.4)=19.4 NOK per trip.[14]

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[13] Börjesson and Eliasson (2012, p. 680) make an argument for applying the "values of time for cycling on a separate bicycle path when converting the values" of facilities per minute "[s]ince 90% of the respondents had access to a separated bicycle path on more than half of the trip"; and this was also the procedure applied by Ramjerdi *et al.* (2010). However, Börjesson and Eliasson (2012) actually apply the value of time for cycling in mixed traffic when converting the values per minute to Euro values. We propose to apply the average bicycling value of time since our sample of cyclists reported a variation of the share of the trip on separated facilities going from none to all and approximately equal numbers with less than half as with more than half of the trip on separated cycling facilities (Table 5).

[14] A slightly different model specification was also tried, in terms of re-arranging the attribute-specific constant (ASC) to either the "safer" or "riskier" alternative (based on the casuality attribute), where the difference between the ASC can be interpreted as preference for safety *per se* when travelling (Veisten *et al.* 2012). The resulting estimated WTP for a casualty reduction, based on this alternative modelling, was NOK 21.53 (15.45,27.60) per trip, which yields a VSC of NOK 43 millions, a VSL of NOK 120 millions (86,153), and a VSSI of NOK 24 millions (17,31). The value of a crossing (stop/intersection) was 0.99 cycling minutes, yielding 2.52 NOK (1.92, 3.11) per elimination of stop per cycling trip. And finally, the marginal value of a separated cycling facility was 0.34 cycling

The specific wave 2 estimate of the casualty per cycling minute is 18.35 versus 23.37 in the joint mixed logit model. Multiplying by 2.73 (the value of cycling time in minutes), this yields, respectively, 50.10 NOK and 63.81 NOK per trip. For the calculation of values of statistical casualties (VSC), and VSL and VSSI, we will apply an AADT of 5500, for the roads that the bicyclists followed and/or crossed, since this represents the weighted average for the three AADT classes (2000, 6000, 12000) that the respondents were assigned to, and could partly correct. A WTP of 50.10 NOK per casualty reduction per trip yields a value of a statistical casualty (VSC) of 100.6 million NOK; while a WTP of 63.81 NOK yields a VSC of 128.1 million NOK. Assuming that the relative risk of fatality and serious injury, for every casualty, is 0.2 vs. 0.8, and that the death rate equivalent (DRE) of a serious injury is 0.2, the VSC estimates yield VSL of respectively NOK 279.5 mill and NOK 355.8 mill; while the VSSI estimates are respectively NOK 55.9 mill and NOK 71.1 mill. These value estimates are quite sensitive to the AADT estimate (Hensher *et al.* 2009, Veisten *et al.* 2012).[15]

minutes, or 0.92 NOK (0.78,1.06); and for an average trip length of 7 km, the implicit value of a km separate cycling facility then became 0.92·(100/7)=13.1 NOK (11.1,15.0).

[15] E.g., an AADT of 7000 would yield VSC estimates of 43 million NOK for a WTP of 16.88 NOK per casualty reduction per trip and NOK 58 million for a WTP of 22.62 NOK. This would yield VSL of respectively NOK 120 mill and NOK 160 mill; while the VSSI estimates would be respectively NOK 24 mill and NOK 32 mill.

5. Discussion and conclusions

We have carried out simultaneous choice-based valuation of barrier-reducing facilities and accident risk, as well as the comparison against choices not including the accident risk attribute. To our knowledge, such choice experiments have not been described in the literature. Similar to the approach in former choice experiments involving bicycling, the monetary valuation of bicycling qualities was established from choices between cycling and an alternative mode that included a cost attribute (Wardman *et al.* 1997, Wardman 2007, Börjesson and Eliasson 2012). The stated choice experiment was, to a considerable degree, pivoted to respondents' actual trips, applying the reported reference levels for time use, and creating a casualty (safety) attribute from the time use combined with accidents statistics (Elvik 2008). The other attributes (barrier-reducing facilities) were also to some extent varying around the level reported for the reference bicycling trip in order to enhance the realism of the choice settings. As the main purpose of this research was to estimate unit values, at the Norwegian national level, for time savings, km of separate cycling paths, eliminated stops/crossing, and casualty reductions (Samstad *et al.* 2010), our internet-based approach was generalised to fit any reference cycling trip above 10 min (but omitting recreational and exercise cycling).

The within-mode choice experiment for cyclists was carried out with and without the casualty attribute. This specific feature of the study allowed to investigate to what degree the valuation of cycling facilities (separate cycling facilities and eliminations of intersections with motorised traffic) encompassed a perceived safety gain provided by the facilities. Based on formal testing, we reject the null hypothesis of equal valuation independently of the inclusion of the casualty attribute. Indeed, the valuation of the two facilities almost halved. The estimated valuation for as elimated intersection reduces from 3.85 NOK to 2.14 NOK and the valuation of a 1% increase in separate path reduces from 1.34 NOK to 0.78 NOK. The reduced values can then be seen as valuation of the facilities iself (that is, the improvement in comfort and convienience) "controlling for" the utility associated with casuality risk-reduction. As casualty risk might not include all perceived aspect of safety, these valuations might however encompass utility to avoid less-severe accidents (e.g. slight injury from a collision with a pedestrian).

The disutility of longer travel time, or delays, due to barriers like crossings, can be supposed to have been controlled for through the travel time attribute, which was included in all presented choice experiments For cost-benefit analysis it is seemingly desirable to obtain valuations of isolated effects, e.g., the inconvenience of crossings/intersections when controlling for casualty risk and time use effects, since there already exist time and casualty valuations in the cost-benefit analysis tools of the transport sectors, e.g., in Norway. In this way the potential for double counting will be reduced.

In general, the valuation of separate cycling paths was substantial, and thus well in line with results from former research (Wardman *et al.* 2007, Parkin *et al.* 2007, Börjesson and Eliasson 2012). Although an implicit safety valuation for separate paths might be considered as objectively wrong (Stone and Broughton 2003, Veisten *et al.* 2005, Elvik *et al.* 2009), there might still be some convenience and comfort quality in separate paths that comes in addition to both safety and time use also when including the safety attribute. This bicycling mobility quality, or barrier-reducing facility, was also shown to be highly valued in a recent Swedish study (Börjesson and Eliasson 2012). Elimination of forced stops due to intersections with motorised traffic yields both improved safety and more convenience and comfort in the bicycling (Abraham *et al.* 2002, Parkin *et al.* 2007). The valuation of the casualty reduction, when specified as an attribute, was substantial as well, and if brought forward to some demand model, or cycling propensity model (Parkin *et al.* 2007), would clearly predict increased cycling as a response to a safety improvement, *ceteris paribus* (Ortúzar *et al.* 2000).

Finally, investigations into preferences for cycling in transport remain relatively sparse compared to the investigations into car driving. We believe more bicycling route choice experiments are warranted, with more diversification in experimental design. We also call for testing of payment mechanisms for cycling facilities, e.g., toll roads compared to shelter charges (Ortúzar *et al.* 2000), or work-related or school-related subsidies, e.g., reduction of subsidies related to improved cycling route facilities.

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Table 1: The time attribute (*t*) in choice experiments (CE), with base levels from cyclists' reported trip length (min) on reference trip

Base time of trip (min)	Change in time of the trip relative to base time (min)				
	level -2	level -1	level 0	level 1	level 2
10 – 19	-4	-1	0	3	6
20 – 44	-4	-1	0	3	6
45 – 74	-5	-2	0	3	8
75 – 119	-10	-5	0	5	18
120 – 179	-12	-5	0	8	20

Note: No cyclist reported trips above 120 minutes.

Table 2: The separate cycling path attribute (SEP**) in the second and third choice experiments (CE), with simplified base levels from cyclists' reported share of separate cycling path on reference trip**

Base level of separated bicycling path, in percent of distance	Default base levels and upward and downward attribute levels, in percent of distance				
	level -2	level -1	level 0	level 1	level 2
> 50%	80%	50%	30%	15%	0%
<= 50%	60%	40%	20%	10%	0%

Table 3: The crossing attribute (CRO**) in choice experiments (CE), with base levels from cyclists' reported no. of crossings on reference trip**

Base no. of stops	Change in no. of stops relative to base no.				
	level -2	level -1	level 0	level 1	level 2
0	0	0	0	1	2
1	-1	-1	0	1	2
2	-2	-1	0	1	2
3	-3	-1	0	1	2
4	-4	-2	0	1	2
5	-5	-3	0	2	3
6-8	-6	-3	0	2	4
9-12	-9	-5	0	3	5
13+	-13	-7	0	4	7

Table 4: Base levels of casualty attribute (CAS**), i.e., fatalities and serious injuries, in choice experiments, derived from cyclists' actual trip length (in time)**

	Mean annual expected number of casualties

Base time (min)	Mean time (min)	Dist-ance (Km)	Initial estimation			Upward adjustment due to underreporting in official statistics, and adaptation to choice experiment		
			AADT 12,000	AADT 6,000	AADT 2,000	AADT 12,000	AADT 6,000	AADT 2,000
10 – 19	15	3	0.66	0.49	0.26	3	2	2
20 – 44	32	6,4	1.40	1.05	0.56	3	2	2
45 – 74	60	12	2.63	1.97	1.05	4	3	2
75 – 119	90	18	3.94	2.96	1.58	6	4	2
120 – 179	150	30	6.57	4.93	2.63	9	7	5

Note: Casualties refer to fatalities and serious injuries. The reported base time of the actual trip was first converted to trip length, by assuming reasonable mean travel speeds, 12 km/hour, based on the national travel behaviour survey from 2005 (Denstadli *et al.* 2006). For the estimation of fatality/injury risk per trip length it was assumed that the route used would have an injury/fatality risk close to the mean value for all cycling routes (Elvik 2008). No cyclist reported trips above 120 minutes.

Table 5: Descriptive statistics for individual characteristics (*n*=1,573)

	Mean	Minimum	Maximum
Age	45.3	17	81
University degree	0.709	0	1
Net personal monthly income (NOK)	23,088	2500	55,000
Income missing	0.0493	0	1
Gender (1 for males)	0.587	0	1
Daily travel distance by bicycle, km*	8.59	0	232
Bicycle trip length (> 10 min), km	6.38	0.2	38
Number of crossings per bicycle trip (> 10 min)	7.29	0	99
Number of crossings per km travelled	1.53	0	10
Zero share of the reported trip on separated cycling facility	0.19	0	1
Less than half of of the reported trip on separated cycling facility	0.26	0	1
About half of of the reported trip on separated cycling facility	0.18	0	1
More than half of of the reported trip on separated cycling facility	0.30	0	1
All the reported trip on separated cycling facility	0.07	0	1

Note: This only includes the respondents responding to both wave 1 and wave 2. The daily distance cycled would drop to 8.32 km if reported daily distances of over 60 km were excluded.

Table 6: Logit modelling of first-step between-mode choice experiment

	Single bicycle time parameter and specific segregated path parameter		Two bicycle time parameters, with and without segregated path	
	multinomial logit	mixed logit (error component)	multinomial logit	mixed logit (error component)

	Estimate	Rob st. error	Estimate	Rob st. error	Estimate	Rob st. error	Estimate	Rob st. error
ASC_bic	1.16	0.0596	2.42	0.182	1.67	0.0580	3.28	0.180
SIGMA_bic			2.53	0.0998			2.48	0.100
B_cost_alt	-0.0302	0.00239	-0.0534	0.00429	-0.0303	0.00237	-0.0527	0.00421
B_t_alt	-0.0437	0.00444	-0.0748	0.00815	-0.0441	0.00442	-0.0760	0.00801
B_t_bic	-0.0783	0.00184	-0.146	0.00522				
B_t_bic_seg1					-0.0673	0.00177	-0.124	0.00484
B_t_bic_seg0					-0.0904	0.00213	-0.167	0.00566
B_t_alt	1.05	0.0431	1.90	0.0890				
B_seg_path	1.16	0.0596	2.42	0.182	1.67	0.0580	3.28	0.180
Obs.	12000		12000		12000		12000	
Respondents	12000 (pseudo)		1500		12000 (pseudo)		1500	
Null Log L (LL_0)	-8317.766		-8317.766		-8317.766		-8317.766	
Constant Log L (LL_C)	-8312.485		-8312.485		-8312.485		-8312.485	
Final Log L (LL_F)	-6648.060		-5273.747		-6714.433		-5374.465	
Adj. rho-square	0.200		0.365		0.192		0.353	

Note: All models were estimated using BIOGEME (Bierlaire 2003). Robust t-tests were computed taking into account the repeated observations nature of the data.

Table 7: Logit modelling of second-step within-mode choice experiment, including accident risk attribute in wave 2 (w2) but not in wave 1 (w1)

	Joint parameters				Wave-specific parameters except for the bicycling time parameter			
	multinomial logit		mixed logit (random coefficient)		multinomial logit		mixed logit (random coefficient)	
	Estimate	Rob st. error	Estimate	Rob st. error	Estimate	Rob st. error	Estimate	Rob st. error
ASC_left	(-0.0146)	-0.67	(-0.0156)	0.0300	(-0.0155)	0.0199	(-0.00735)	0.0285
B_t_w1w2	-0.0902	0.00355	-0.166	0.0108	-0.0840	0.00380	-0.158	0.0112
B_CRO_w1w2	-0.100	0.00596	-0.199	0.0146				
SIG_CRO_w1w2			0.209	0.0177				
B_CRO_w1					-0.104	0.00637	-0.223	0.0164
SIG_CRO_w1							0.225	0.0183
B_CRO_w2					-0.0575	0.00893	-0.124	0.0175
SIG_CRO_w2							(0.00821)	0.0165
B_SEP_w1w2	0.0405	0.00117	0.0754	0.00422				
SIG_SEP_w1w2			0.0799	0.00424				
B_SEP_w1					0.0412	0.00114	0.0830	0.00444

SIG_SEP_w1							0.0796	0.00422
B_SEP_w2					0.0251	0.00202	0.0452	0.00496
SIG_SEP_w2							0.0634	0.00723
B_CAS_w2	-2.04	0.111	-3.88	0.300	-1.42	0.103	-2.90	0.291
SIG_CAS_w2			2.77	0.221			2.06	0.214
Scale_w2	0.516	0.0304	0.510	0.0445	0.750	0.0574	0.689	0.0737
Obs.	17594*		17594*		17594*		17594*	
Respondents	17594 (pseudo)		1500 (2968**)		17594 (pseudo)		1500 (2968**)	
Null Log L (LL_0)	-12195.231		-12195.231		-12195.231		-12195.231	
Constant Log L (LL_C)	-12194.504		-12194.504		-12194.504		-12194.504	
Final Log L (LL_F)	-9304.911		-8242.755		-9280.718		-8201.474	
Adj. rho-square	0.237		0.323		0.238		0.326	

Note: All models were estimated using BIOGEME (Bierlaire 2003). Robust t-tests were computed taking into account the repeated observations nature of the data. The actual number of respondents in the analyses was 1500 in the wave 1 part and 1484 in the wave 2 part (since some respondents always choose the opt-out in wave 2). Regarding the mixed logit (random parameter logit) modelling, BIOGEME does not allow that a random variable has different scales for different choices of the same respondent, such that the respondent ID has to be split opp, i.e., doubled. There is one respondent for whom no information about this within-mode game in wave 1 was available, supposedly because the respondent dropped out after the between-mode choice experiment in wave 1, but afterwards the respondent participated in wave 2, completing the wave 2 within-mode choice experiment.

Figure 1: Presentation of choice pairs for between-mode choice experiment

Consider two alternative trips:

Trip A: Public Transport	Trip B: Bicycling
Total time: t_A min Total cost: NOK c_A	Total cycling time: t_B min Separate cycle path: all the way (SEG=1)

Which one do you prefer?

☐ ***Trip A*** ☐ ***Trip B***

Figure 2: Presentation of choice pairs for the first within-mode choice experiment

Consider the following two trips as cyclist:

Trip 1:	Trip 2:
Total cycling time: t_1 min Share on separate cycle path: SEP_1 % No. of stops: CRO_1	Total cycling time: t_2 min Share on separate cycle path: SEP_2 % No. of stops: CRO_2

Given everything else the same, which one do you prefer?

☐ **Trip 1** ☐ **Trip 2**

Figure 3: Presentation of choice pairs for the second within-mode choice experiment

Consider the following two trips as cyclist:

Trip 1:	Trip 2:
Total cycling time: t_1 min Share on separate cycle path: SEP_1 % No. of stops: CRO_1 No. of fatalities and seriously injured: CAS_1	Total cycling time: t_2 min Share on separate cycle path: SEP_2 % No. of stops: CRO_2 No. of fatalities and seriously injured: CAS_2

Given everything else the same, which one do you prefer?

□ **Trip 1** □ **Trip 2**

Figure 4. Two-wave internet-based survey